09/830479

PCT/AU99/00930

REC'D 09 DEC 1999	
WIPO	PCT

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I, KIM MARSHALL, MANAGER PATENT OPERATIONS hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PP 6795 for a patent by AGSYSTEMS PTY LTD filed on 27 October 1998.

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Second day of December 1999

KIM MARSHALL
MANAGER PATENT OPERATIONS

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VEHICLE POSITIONING APPARATUS AND METHOD

FIELD OF INVENTION

This invention relates to vehicle positioning apparatus and method.

This invention has particular but not exclusive application to a system, method, and computer program for precise guidance of an agricultural vehicle and possible associated attachments and to a method and computer program for extraction of geographical data, and for illustrative purposes reference will be made to such application. However, it will be appreciated that this invention could be used in general application to other vehicles, including land-based vehicles, marine vessels and aircraft.

In this specification, the following abbreviations will have the meanings indicated unless the context demands otherwise:

GPS	Global Positioning System
DGPS	Differential Global Positioning System
WADGPS	Wide Area Differential Global Positioning System
PCB	Printed Circuit Board
I/O	Input / Output
LCD	Liquid Crystal Display
DOS	Disk Operating System
RS 232	Serial Cable Interface Standard
MOSFET	Metal Oxide Semi-Conductor Field Effect Transistor

The Global Positioning System (GPS) is a space-based radio positioning system which provides suitably equipped users with highly accurate position, velocity and time data. The system provides this data continuously from a network of twenty-four (24) satellites to locations on or near the surface of the earth.

The GPS system provides two separate transmissions; an extremely high accuracy military transmission, and a slightly degraded civilian transmission. The civilian transmission contains errors which are intentionally introduced in order to lower the accuracy of the position data obtained. However, it is known that by providing two receivers, one of which has a fixed and known location, such errors may be eliminated.

There are two methods which may be utilised to overcome the inclusion of such inaccuracies, providing an extremely accurate source of positional, time and velocity data. These methods used are Differential GPS (DGPS) and Wide Area Differential GPS (WADGPS). Both of these methods are described below.

DGPS is a standard technique used to significantly increase the accuracy provided by the GPS. This method requires the use of a base station consisting of a GPS receiver, a data radio and a mobile GPS receiver unit. Using the fixed and known position of the base station, it is possible to determine the inherent error associated with the GPS signal. This error signal is transmitted to the mobile unit via data radio, providing a correction factor which is used to correct the GPS signal received by that unit.

WADGPS differs from DGPS by means of modeling the effect of the atmospheric conditions present above the area of operation of the system. DGPS signals from a "pseudo base station" located directly over the mobile units are then calculated, eliminating errors associated with distance from the base station

DESCRIPTION OF THE PRIOR ART

Traditional farming methods require an agricultural vehicle, such as a tractor, harvester or such like, to be driven back and forth across a field in substantially parallel rows adjacent, and preferably, abutting one another. However, factors such as varying seasonal conditions, undulating terrain, driver fatigue and such like are often responsible for significant inefficiencies including inaccurate estimation of the locations or the rows which in turn may result in an overlap or an over-spacing between adjacent rows. As a consequence of field compaction sections of compacted field may exhibit reduced fertility.

SUMMARY OF THE INVENTION

The present invention aims to alleviate one or more of the above disadvantages and to provide a vehicle positioning apparatus and method which will be reliable and efficient in use.

With the foregoing in view, this invention resides broadly in a vehicle positioning apparatus including:

fixed receiver means for receiving a first set of signals from a GPS navigational aid;

movable receiver means for receiving a second set of signals from a GPS navigational aid and operatively associated with a vehicle;

signal processing means for processing said first and second sets of signals whereby the present position of said vehicle is determined, and

output means adapted to provide output signals to an output device.

In another aspect, this invention resides broadly in a vehicle positioning apparatus including:

position determining means for determining the position of a vehicle and providing information in respect of said position;

processing means in operative connection with said positioning determining means for processing the information;

output means operatively connected with said processing means for providing output signals to an output device.

The position determining means may include an array of positioning beacons which act in concert with a movable receiver or such like, or may be comprised in a fixed receiver means for receiving a first set of signals from a GPS navigational aid and a movable receiver means for receiving a second set of signals from a GPS navigational aid.

The output device may include indication means adapted to indicate an actual and/or preferred position and/or speed and/or direction of the vehicle. The vehicle positioning apparatus may also include control means operatively associated with the output device for controlling the movement of said vehicle, and program means for providing commands to said control means whereby said vehicle may be instructed to follow a desired route using the information provided by the output means. Suitably, the output device is operatively attached to the vehicle.

Preferably, the fixed and movable receiver means utilise DGPS or WADGPS to provide an accurate time, velocity and position signal in operative association with the signal processing means and the output means. The signal processing means and the output means provide information substantially continuously.

The vehicle positioning apparatus may also include display means providing a visual indication of the position and/or speed, and/or direction of travel or the vehicle, and

wherein this information may be superimposed upon a map showing the route which the vehicle is to follow.

Preferably, the route includes a pattern for the coverage of a field, such as a pattern of substantially parallel or non-converging lines or curves spaced apart in accordance with the operative width of the vehicle. The steering of the vehicle may be controlled by the control means, and for this purpose, the throttle of the vehicle powering the vehicle, brake system, steering system, such as the orientation of the steered wheels and such like may be also controlled by the control means. For example, where a powered implement is attached to the vehicle, the control means may be programmed to activate and deactivate the power to the implement, to raise and lower the implement, and/or to orient the implement as required.

Preferably, the vehicle positioning apparatus is adapted for use within the agricultural industry. It is believed that the present invention allows operators to carry out agricultural vehicle-based operations in a significantly more efficient and cost effective manner than has been previously possible. These improvements are achieved by minimising the errors inherent in traditional farming operations, by utilising the positioning abilities of the GPS. GPS is however, only used as a means for providing navigational data, and other navigation systems may be employed for this purpose.

The fixed receiver means may include a fixed base station, the location of which is accurately known. Alternatively, the fixed receiver means may include a transportable base station, which may be transported to any one of a plurality of accurately known base locations and programmed with data relevant to the base location where the transportable base station is to be used.

The movable receiver means may include a mobile unit.

The vehicle position apparatus preferably is operable in one of two different modes. Mode One, hereinafter referred to as M1, is characterised by a graphical output of the processed GPS data predominantly to a display unit. By virtue of this graphical output, the vehicle position apparatus assists the operator of the agricultural vehicle in maintaining the position of the agricultural vehicle and its associated implement relative to the preferred travel path displayed on the output device. In this mode, the vehicle operator uses the

graphical output to position the vehicle accurately, using the controls of the vehicle in the normal manner. The graphical output is preferably adapted to provide not only the position of the vehicle and its disposition with respect to, for example, the row to be operated on, but also the directional heading of the vehicle.

Mode Two, hereinafter referred to as M2, is characterised by the graphical output of the processed GPS data to a display unit, as well as the output of specifically calculated timed pulses to a steering control unit of the agricultural device. By virtue of this timed, pulsed output, the vehicle positioning apparatus controls the steering, and thereby, the direction of the agricultural vehicle when in motion in order to maintain accurate positioning of the agricultural vehicle and its associated implement.

In applying the capabilities of the vehicle positioning apparatus of the present invention, it is believed that operators can obtain significant savings in fuel, time, chemicals, seed and other factors, whilst enjoying significant agronomic benefits as mentioned above.

DESCRIPTION OF THE PREFERRED FIGURES

In order that this invention may be more readily understood and put into practical effect, reference will now be made to the preferred embodiments described in relation to the accompanying drawings, wherein:

Fig. 1 is a diagrammatic representation of a wide area differential global positioning system (WADGPS);

Fig. 2 is a diagrammatic representation of a differential global positioning system (DGPS);

Fig. 3 shows a wheel angle sensor for a vehicle positioning apparatus, showing the positional relationship of the sensor, magnet and the mounting arm;

Fig. 4 shows a flow diagram of the Main Routine in the Software Module;

Fig. 5 shows a flow diagram of the Initialisation Routine in the Software Module;

Fig. 6 shows a flow diagram of the Flag Check Routine in the Software Module;

Fig. 7 shows a flow diagram of the Receive and Process New GPS Data Routine in the Software Module;

Fig. 8 shows a flow diagram of the De-Initialisation Routine in the Software Module;

Fig. 9 shows a flow diagram of the Steering Control Routine in the Software Module;

Fig. 10 shows a flow diagram of the GPS Data Ready Interrupt Driven Routine in the Software Module;

Fig. 11 shows a flow diagram of the System Timer Tick Interrupt Driven Routine in the Software Module;

Fig. 12 shows a flow diagram of the Process User Input Routine in the Software Module;

Fig. 13 shows a flow diagram of the Process User Input Routine in the Software Module.

Fig. 14 shows a flow diagram depicts the structure of the Process User Input Routine in the Software Module.

Fig. 15 shows a flow diagram of the Process User Input Routine in the Software Module.

Fig. 16 shows a flow diagram of the Process User Input Routine in the Software Module.

Fig. 17 shows a flow diagram of the Process User Input Routine in the Software Module.

Fig. 18 shows a circuit diagram of part of the internal structure of The Beeline Navigator Hardware Module showing all inter-connections and interconnections between module components and input and output sockets.

Fig. 19 shows a circuit diagram of the I/O interface located in The Beeline Navigator Mobile Unit Hardware Module.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Fig. 1, a vehicle positioning apparatus in the form of a WADGPS 10 makes use of a plurality of satellites 11 orbiting within radio range of a base station 12 and a mobile unit 13. The base station 12 and mobile unit 13 receives signals from two or more

satellites 11 in order to provide information (data) regarding the location of the position of the base station and mobile unit respectively on the surface of the earth.

The location of the base station 12 is accurately known so any error inherently contained in the signal received by the base station 12 from the satellites 11 can be corrected.

The base station 12 includes a GPS antenna 14 and GPS receiver 15. The GPS receiver 15 transmits a signal to a work station 16 which processes an error signal. The workstation sends the error signal to a data radio 17 which transfers same to an emitter 18. An error signal 19 is emitted from the emitter and received by an antenna 22 on the mobile unit 13. The mobile unit has its own GPS antenna 14 and GPS receiver 15 and receives the signal through the error signal 19 through its antenna 22.

The signals received through the data radio 17 on the mobile unit 13 and the GPS antenna 14 and GPS receiver 15 on the mobile unit 13 are fed into an on-board computer 20 and processed. The processed signal is converted into a meaningful output provided to a monitor 21 and an output signal line 23 which provides a signal such as for example to a steering monitor or control unit.

The workstation 16 includes means for calculating the necessary error corrections for atmospheric conditions, topographical and such like in accordance with WADGPS practice.

Referring to Fig 2, a DGPS 30 includes the satellites 11 in the same fashion as described in relation to Fig 1. The DGPS includes a transportable base station 31 and a mobile unit 13 having the same configuration as that described in relation to Fig 1. However, the transportable base station 31 includes only the GPS antenna 14, the GPS receiver 15, and the data radio 17. The data radio 17 includes an emitter 32 which emits an error signal 33 which does not include atmospheric and typographical corrections as in the case of the error signal 19 described in relation to Fig 1.

Referring to Fig 3, a wheel angle sensor 40 includes a magnet 41 and a sensor 42 coaxially aligned with the magnet 41. A mechanical linkage 44 to a steering arm 43 on the vehicle moves the sensor 42 within the magnet 41 and produces a steering position signal.

The steering position signal which can be transmitted to the on-board computer 20 in the WADGPS 10 or DGPS 30 described in relation to Figs 1 and 2 respectively.

The vehicle position apparatus of the present invention is a system enabling accurate farming techniques to be completed by persons familiar with traditional farming methods.

The vehicle position apparatus operates in one of two configurations for any particular installation. The first configuration is comprised in the fixed base station 12 using the WADGPS 10 described in respect of Fig. 1. The second configuration is comprised in the transportable base station 31 using the DGPS 30 described in respect of Fig. 2.

The mobile unit 13 required in each configuration is identical, however the particular configuration and transmission distance required determines whether the first configuration or second configuration is used. The maximum transmission distance available using the first configuration is twenty-five kilometres (25km). Dependant on the choice of base station is the format of the GPS correctional data transmitted to the mobile unit 13.

The WADGPS and DGPS described in respect of Figs. 1 and 2 include commercially available technology to receive and decode the GPS signals, and to determine position, heading, and velocity information. The commercially available technology consists of the satellites 11, the GPS receiver 15, the GPS antenna 14, the UHF data radio 17, and the radio tower emitter 18, connected as shown in Fig. 1.

Software operating on the on-board computer 20, hereinafter referred to as the software module, and on the workstation 16 enables connection and communication between the base station 12, the mobile unit 13 and the GPS receiver 15. Note that the components for the mobile unit 13 are attached to or installed in a vehicle, preferably an agricultural vehicle. The GPS data received at the base station 12 is then processed by the software running on the workstation 16 in order to develop an atmospheric model which is used to correct the data received by the mobile unit 13.

With reference to Fig. 2, the transportable base station 31 and DGPS system 30 use similar GPS receiver hardware to receive and decode the GPS signals as described in

relation to Fig. 1, and to determine the position, the heading, and velocity information. The commercially available technology used in this configuration consists of the GPS receiver 15, the GPS antenna 14, and the UHF data radio 17 connected as shown in Fig. 2.

The mobile unit 13 is identical to that used in base station configuration described in respect of Fig. 1. The software is adapted to determine automatically which system configuration is being used.

The vehicle positioning apparatus of the preferred embodiment operates in two modes as described above, one mode being used for the first configuration and the other for the second configuration. The first mode is characterised by the graphical output of the processed GPS data predominantly to the monitor 21. The second mode is characterised by the graphical output of the processed GPS data to the monitor 21, as well as the output of specifically calculated timed pulses to a steering control unit operatively associated with the agricultural vehicle. M2 is known as the 'Steering Assist' mode and is facilitated by the software module and a steering control system.

The on-board computer 20 may be considered to be a hardware module programmed with and a software module. With reference to Fig. 18, the hardware module includes an AT compatible 80386SX computer system, an input/output (I/O) printed circuit board (PCB), a user information I/O device in the form of a touch panel, a five volt (5 V) power supply unit and various I/O based connectors and wiring-connections housed in a customised enclosure. The hardware module requires an input voltage of twelve volts direct (12 V DC) which is supplied by the agricultural vehicle power supply.

The 80386SX computer system is used to run a DOS-based software module, which facilitates the interpretation and display of the corrected GPS data, and produces the output pulses required by the steering control system. The computer system includes four (4) components, namely an 80386 microprocessor, a four (4) port RS 232 interface module, a 4 megabyte flash solid state storage device and a data acquisition module. These components can be seen in Fig. 18 as the PCM 3864, PCM 3640, PCM 3820 and PCM 3718 respectively. The RS 232 interface module is used to facilitate data transfer between the GPS receiver, the radio modem and the processor.

With reference to Fig. 19, the I/O interface facilitates the connections between the steering control system and the microprocessor. Digital outputs from the computer system are connected via an arrangement, as depicted in Fig. 19, to the agricultural vehicle's hydraulic steering control solenoids. This connection is made such that upon a high output from the computer system's digital outputs, current is sunk from the agricultural vehicle's power supply through computer system I/O, facilitating the solenoid action.

The interface circuits are particularly versatile and may quite readily be used to for the I/O of various control signals to and/or from other devices within or in the vicinity of the agricultural vehicle.

The user information I/O device includes a Liquid Crystal Display (LCD) with a touch panel screen. This touch screen device is connected to the computer system via the RS 232 Module as shown in Fig. 18. The computer system provides the power supply and data signals for the LCD Panel. The touch screen provides an intuitive interface for the input of data from users, as well as displaying the vehicle heading relationship and other information in an easy to understand graphical format.

The I/O–based connectors displayed in Fig 18 facilitate up to ten (10) twelve volt (12V) digital inputs from devices within or in the vicinity of the agricultural machinery as well as up to four (4) twelve volt (12V) digital outputs. In the case of the digital inputs, the field device must provide the twelve volt (12V) switching potential. The digital inputs are non-inverting, thus an input of twelve volts (12V) is recognised as a high state by the software module. The digital outputs are solely controlled by the software module and provide effective control of the field device

In addition to the digital inputs described above, the vehicle of the preferred embodiment can accept up to eight analog inputs from field devices. The analog input must be a differential five volt (±5V) signal. Two connectors are provided for each input in this case. Should the analog signal be ground referenced, the negative analog input must be connected to ground.

Six serial communications ports are also available for use with the vehicle positioning apparatus of the preferred embodiment.

As shown, COM1 is assigned to the Radio Modem, COM2 and COM3 are assigned to the GPS Receiver and COM4 to the LCD display. COM5 and COM6 are free to communicate with other devices.

The software module together with the hardware module form the complete GPS information interpretation and processing system used in apparatus of the present invention. The software module functionality facilitates not only the precision guidance of the agricultural vehicle, but also the logging of data received from the GPS receiver and internally calculated data. This data may be transmitted to the (transportable) base station 12 (13) for future receipt and use in field contour mapping and for driver and agricultural vehicle performance reports. A software module flow chart indicating pertinent software operations is depicted in Fig. 6.

The software module includes a main routine which is depicted in Fig. 4. External to this main routine are system interrupts which indicate the receipt of new GPS data or facilitate the execution of time dependent events. The system interrupt routines are depicted in Figs. 10 and 11.

The user interface for the software module is divided into a series of screens, each relevant to a particular feature or configuration item of the vehicle position apparatus. A process user input routine is displayed in Figs. 12 to 17 to depict the flow of control between the software module screens.

A user interface main screen provides a number of pieces of textual information to the agricultural vehicle operator, as well as a graphical representation of the current position and heading. The textual information is displayed as a header with an associated value. The headers and their relevance to the operation of the vehicle position apparatus of the preferred embodiment are as follows.

WHDG – Waypoint Heading is the angle between a line connecting waypoints one and two, and a line connecting waypoint one and true north. This value is useful for navigation purposes.

HDG – Heading is the current heading with respect to true north. This value is useful for navigation purposes.

SLOP – Slop is the current positional uncertainty. The value is in centimetres and reflects the error inherent in the positional value used for navigational calculations.

XTRK – Crosstrack error is the distance from the desired line of travel to the current line of travel. This value is presented in metres.

SATS – This value corresponds to the number of satellites currently in view by the GPS receiver. The vehicle positioning apparatus of the preferred embodiment requires at least four common satellites in view at all times.

CPU – The CPU parameter represents the current loading on the Hardware Module processor.

% CPU – The %CPU parameter represents the current loading on the GPS card.

The vehicle position apparatus of the preferred embodiment contains a diagnostics function which allows operators to ensure that the system is functioning correctly. The diagnostics features are as follows :

Number of Satellites in View at Mobile Unit – as described in SATS above.

CPU Load on GPS Receiver Card – as described in % CPU above.

CPU Load on Local Processor – as described in CPU above.

Number of Satellites in View at Base Unit - This value corresponds to the number of satellites currently in view by the GPS receiver located at the base station. The vehicle positioning apparatus of the preferred embodiment requires at least four common satellites in view at all times.

Rolling Time Update from the GPS Receiver – This constantly changing time value assures communication with the GPS satellites.

Solenoid Response Test – This test may be performed to ensure the correct operation of the Steering Control solenoids.

Serial Cable Status – This loop-back test performed on the serial cables within the system assures cable continuity.

Analogue Input Range Tests – These tests performed routinely on the applied analogue inputs alert operators to external device faults.

Radio Communication Continuity Test – This routinely performed test alerts operators to radio device faults.

The mobile unit software module for the vehicle positioning apparatus of the preferred embodiment provides safety mechanisms for the agricultural vehicle operator. The inherent safety of the vehicle positioning apparatus of the preferred embodiment is assured through routines in the software module specifically dedicated to verify correct operation of the system, and to provide mechanisms to inhibit the actions of out of range inputs and outputs. The safety features present in the vehicle positioning apparatus of the preferred embodiment include the following :

Anomaly : Vehicle position incorrect by a distance of one metre (1m) or more

Action : Steering Control outputs disabled

Effect : Allows agricultural vehicle driver intervention in the case of an emergency

Anomaly : Wheel angle sensors returning out of range value.

Action : Steering Control outputs disabled

Effect : Allows agricultural vehicle driver intervention in the case of an emergency

Anomaly : Vehicle heading incorrect by an angle of thirty degrees (30°) or more

Action : : Steering Control outputs disabled

Effect : Allows agricultural vehicle driver intervention in the case of an emergency

Anomaly : Hardware Module unable to set wheel angle to the desired value within four seconds (4sec)

Action : Steering Control outputs disabled

Effect : Allows agricultural vehicle driver intervention in the case of an emergency

Anomaly : Position uncertainty greater than fifty centimetres (50cm)

Action : : Steering Control outputs disabled

Effect : Allows agricultural vehicle driver intervention in the case of satellite or receiver down time, or radio data communication lapse

Anomaly : Velocity of agricultural vehicle less than zero point five metres per second (0.5m/s)

Action : Steering Control outputs disabled

Effect : Allows agricultural vehicle driver to perform necessarily low velocity maneuvers with interruption

Anomaly : Velocity of agricultural vehicle greater than five metres per second (5m/s)

Action : Steering Control outputs disabled

Effect : Allows agricultural vehicle driver to perform necessarily high velocity maneuvers without interruption

The vehicle positioning apparatus of the preferred embodiment houses a steering control system which facilitates automatic steering of an agricultural vehicle. The steering control system includes a Proportional-Integral-Differential (PID) Controller which is modeled and effected in the software module. The output of the PID controller is used to set a solenoid control variable which then determines the length and quantity of a series of pulses output to the solenoid control of the agricultural vehicle's hydraulic steering mechanism. The solenoid control pulses are output via the digital output ports through the previously described I/O interface circuits. Several external sensors are used to further refine the Steering Control System function. These sensors are described below.

With reference to Fig. 3, wheel angle sensors are used in the vehicle positioning apparatus of the preferred embodiment in order to determine the degree of steering of the agricultural vehicle's steered wheels. The sensors are based on the Hall effect and can accurately track small changes in a magnetic flux density. The units are comprised of three major components, namely the sensor, the magnet and the mounting arm or mechanical linkage.

As the steering arm moves to steer the steered wheels to the left or right, the sensor rotates within the magnet causing a magnetic flux change. This change in flux is represented by a linear output relationship between the wheel angle and the signal voltage. The wheel angle sensors are supplied with a five volt (5V) and a ground (GND) supply from hardware module. The input signal returned to the hardware module is proportional to angle of rotation of the wheel and is of course limited to the supply voltage.

Fig. 3 shows the relationship between the magnet, sensor and the steering arm.

The vehicle positioning apparatus of the preferred embodiment utilises accelerometers, which measures acceleration in three dimensions, to further increase the accuracy of the steering control system. Due to the limitations of current GPS technology,

positional updates are only available once during every two hundred millisecond (200ms) period. During this time positional values may vary significantly, negatively influencing the accuracy of the steering control system. In order to enhance precision, accelerometers are used to obtain positional data information between the GPS positional data transmissions. Using this additional information, the software module is able to greatly enhance the operation of the steering control system. Accelerometers are connected to the vehicle positioning apparatus of the preferred embodiment via the provided analogue inputs.

The vehicle positioning apparatus of the preferred embodiment also utilises tilt sensors to further increase the accuracy of the Steering Control System. The tilt sensors measure the pitch (relative height of the front of the vehicle with respect to its rear) and roll (relative height of the leftmost side of the vehicle with respect to its rightmost side) of the vehicle to which it is attached. Once again, tilt sensors provide increased sensitivity and accuracy in the steering control system.

Tilt sensors are connected to the vehicle positioning apparatus of the preferred embodiment via the provided analogue inputs.

The vehicle positioning apparatus of the present invention is believed to be a precise vehicle guidance system primarily designed for use within the agricultural industry. The system allows operators to carry out agricultural vehicle-based operations in a significantly more precise, efficient and cost effective manner than has been previously possible.

The vehicle positioning apparatus of the present invention addresses the inefficiencies of the prior art by enabling the precise guiding of the agricultural vehicle and associated implement regardless of external conditions. A real time guidance information screen and/or a vehicle steering assistance feature guides the agricultural vehicle operator to perform his or her tasks accurately. The vehicle positioning apparatus possibly facilitates twenty-four (24) hour farming, and through its data collection components, allows detailed monitoring of driver and agricultural vehicle performance.

It is to be appreciated that the above has been given only by way of illustrative example of the invention and that all such modifications and variations thereto as would be

apparent to persons skilled in the art are deemed to fall within the broad scope and ambit of the invention as is herein defined in the appended claims.

THE CLAIMS OF THE INVENTION ARE AS FOLLOWS:

1. A vehicle positioning apparatus including:

fixed receiver means for receiving a first set of signals from a GPS navigational aid;

movable receiver means for receiving a second set of signals from a GPS navigational aid and operatively associated with a vehicle;

signal processing means for processing said first and second sets of signals whereby the present position of said vehicle is determined, and

output means adapted to provide output signals to an output device.

2. A vehicle positioning apparatus including:

position determining means for determining the position of a vehicle and providing information in respect of said position;

processing means in operative connection with said positioning determining means for processing the information;

output means operatively connected with said processing means for providing output signals to an output device.

a vehicle positioning apparatus including:

position determining means for determining the position of a vehicle and providing information in respect of said position;

processing means in operative connection with said positioning determining means for processing the information;

output means operatively connected with said processing means for providing output signals to an output device.

DATED THIS TWENTY-SEVENTH DAY OF OCTOBER, 1998

AGSYSTEMS PTY LTD ACN 067 397 086

BY

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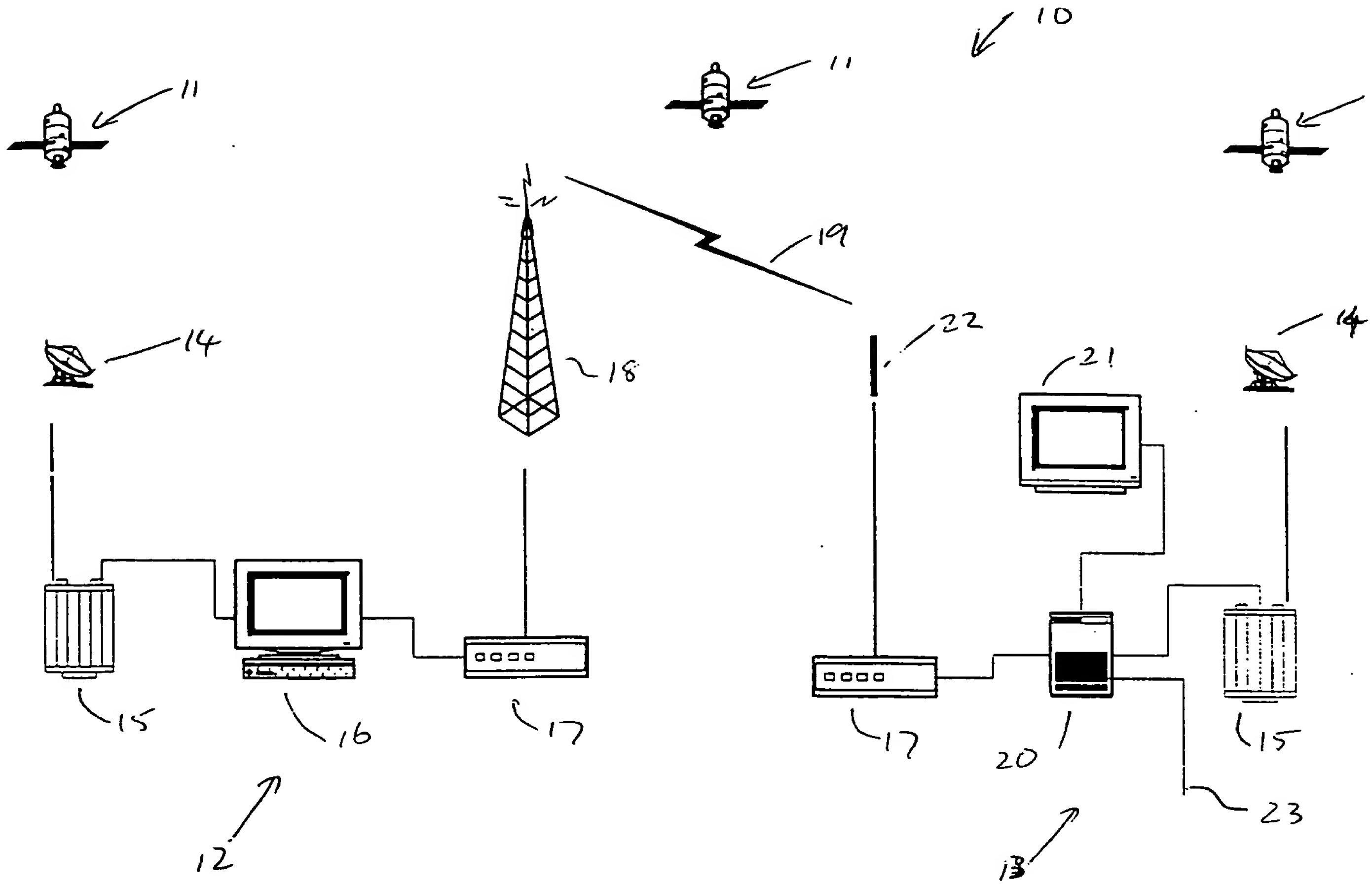


Fig. 1

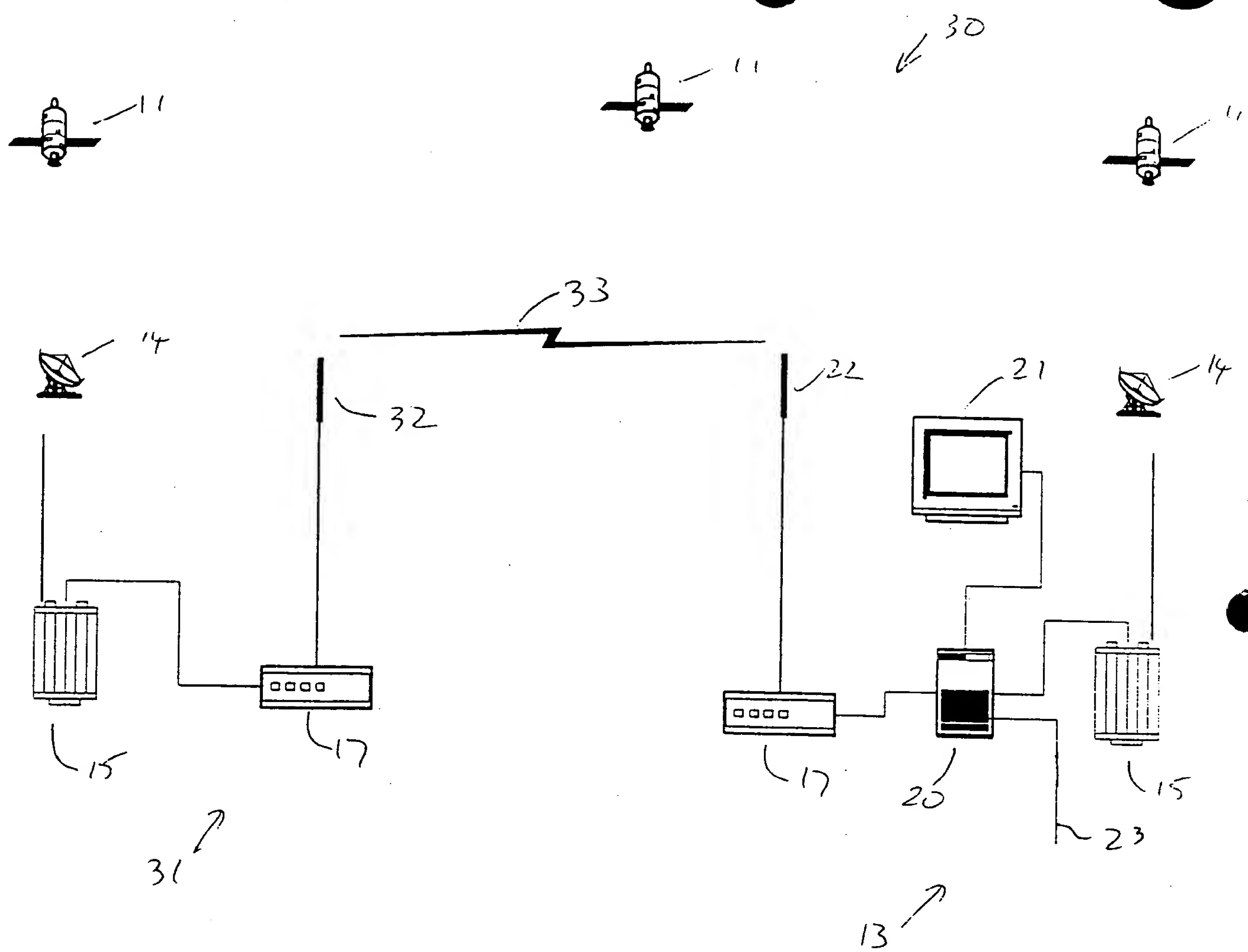


Fig. 2

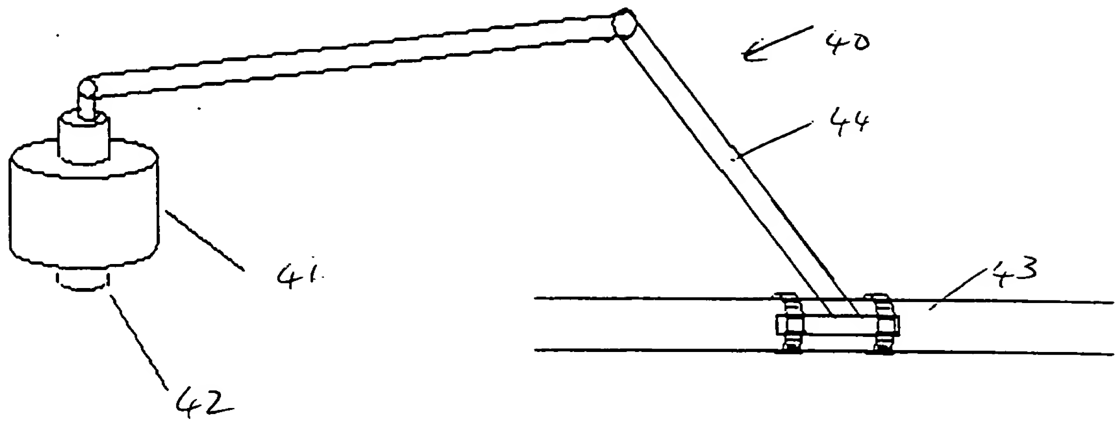
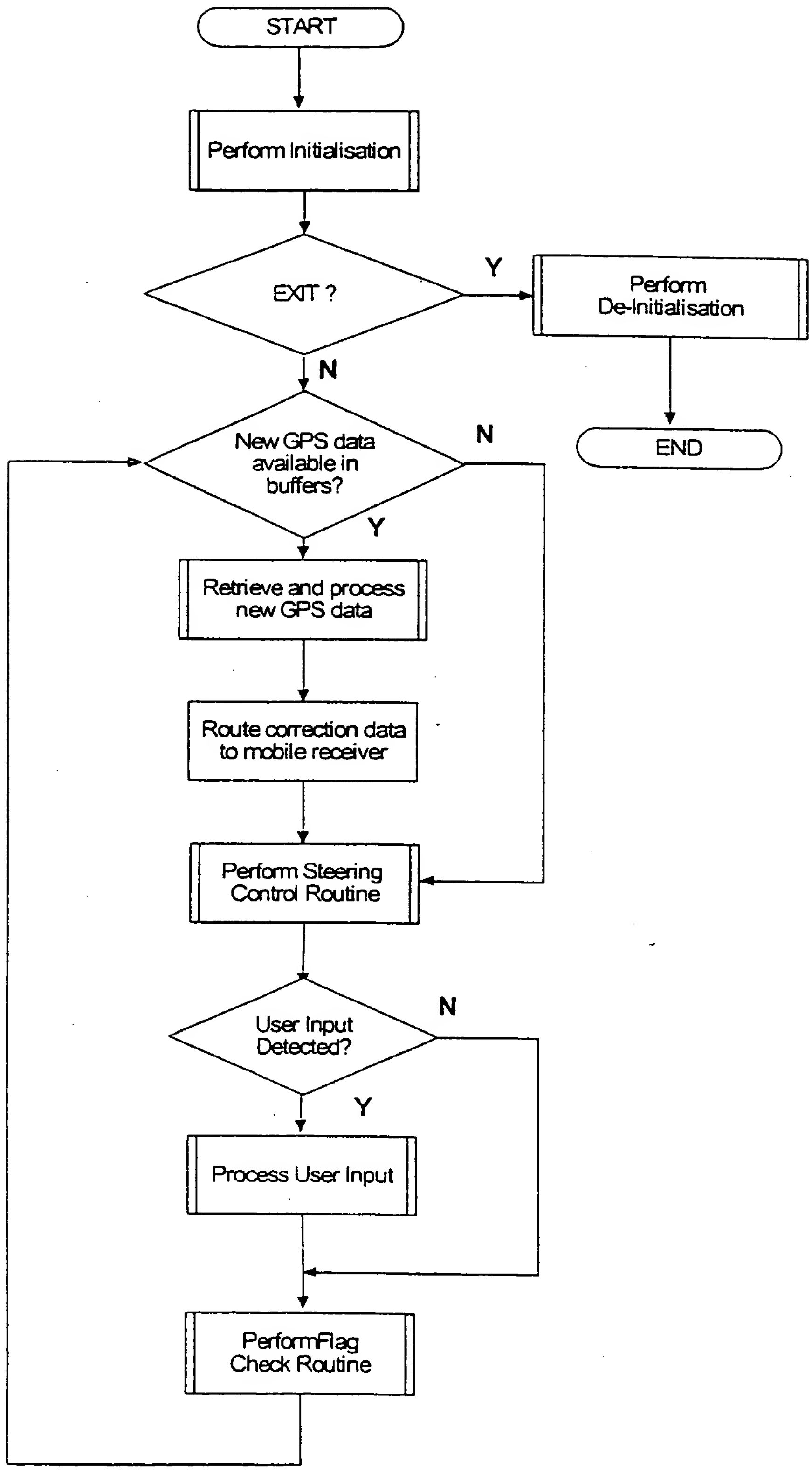
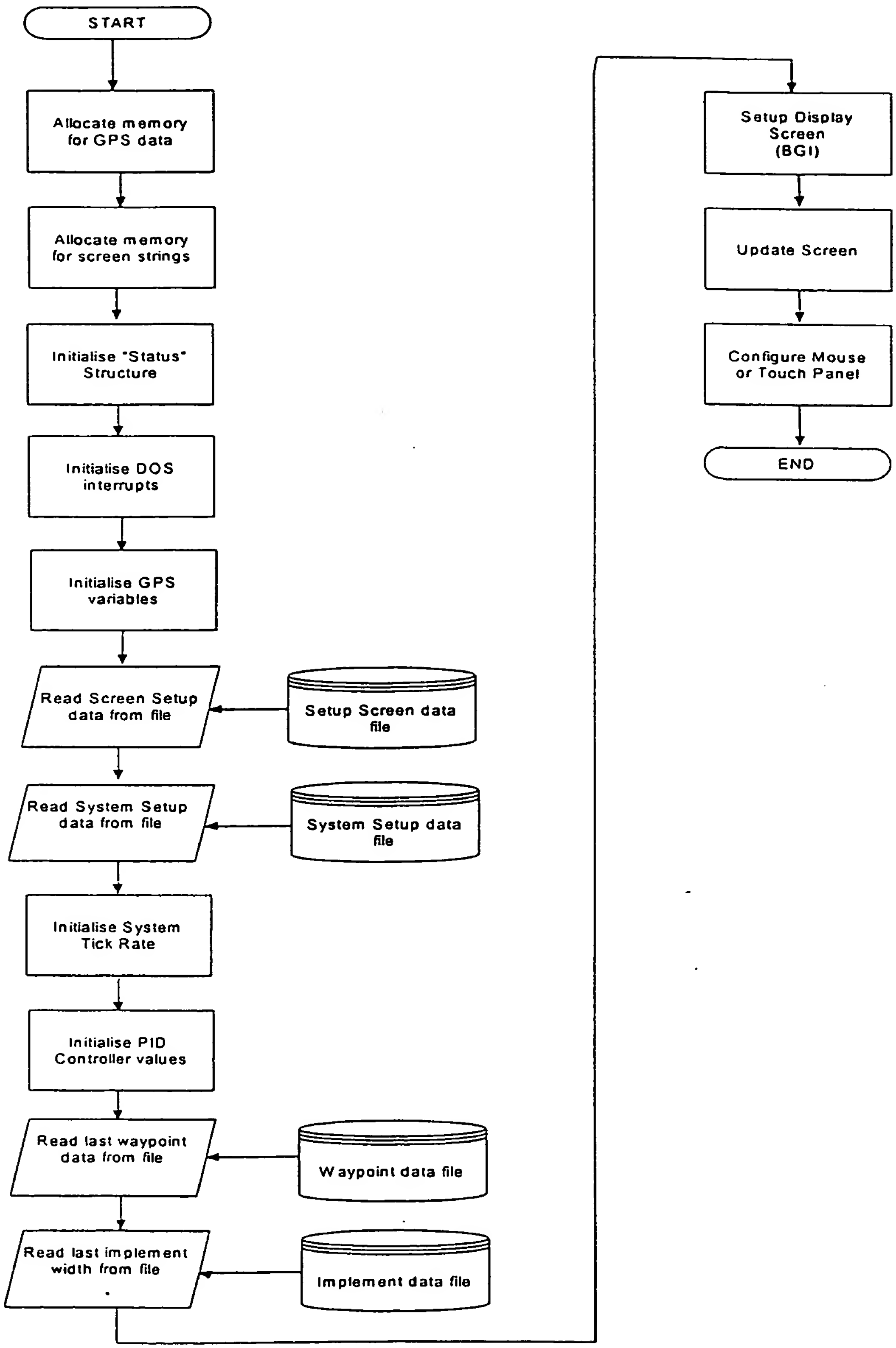


Fig. 3

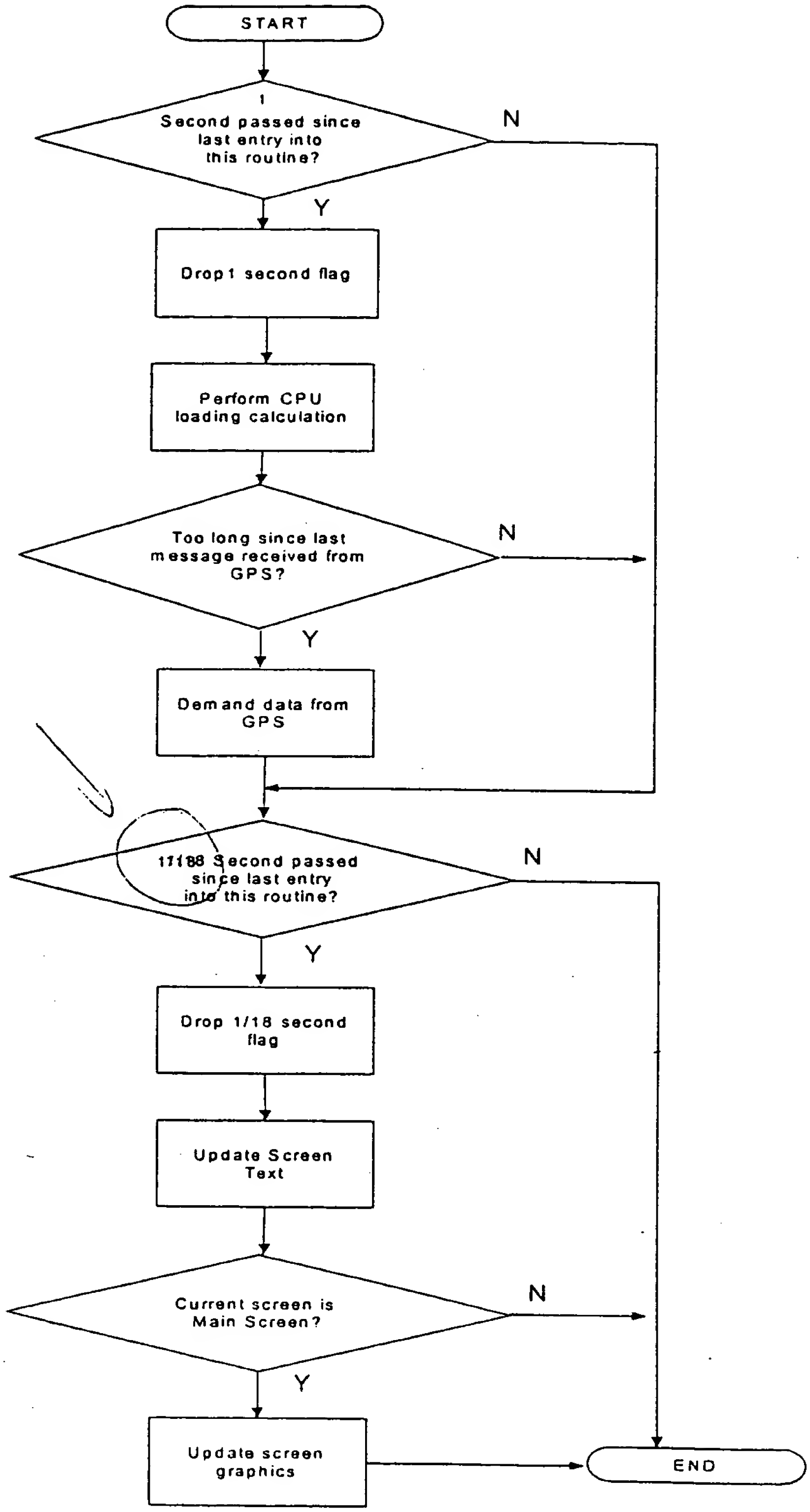
Main Routine



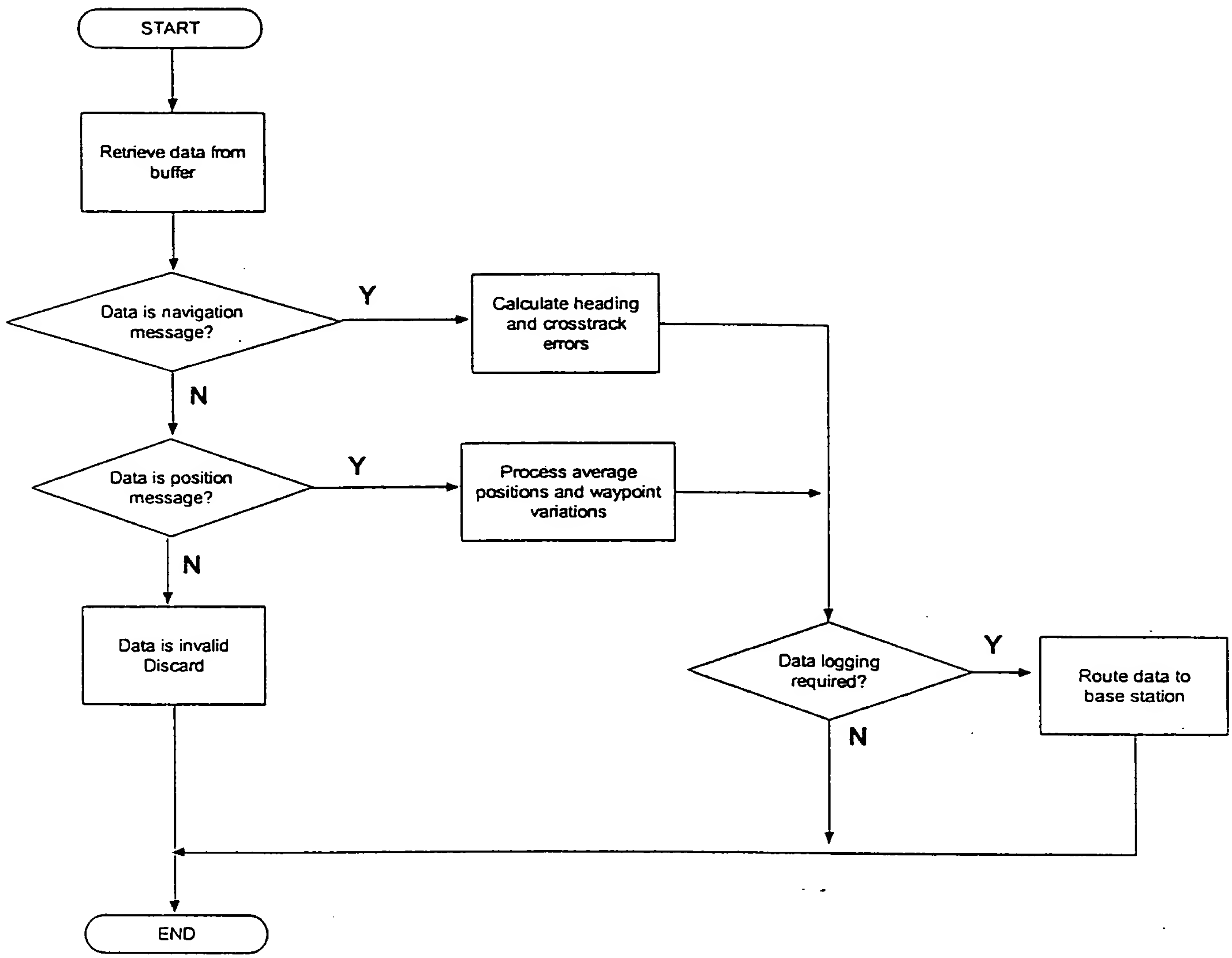
Initialisation Routine



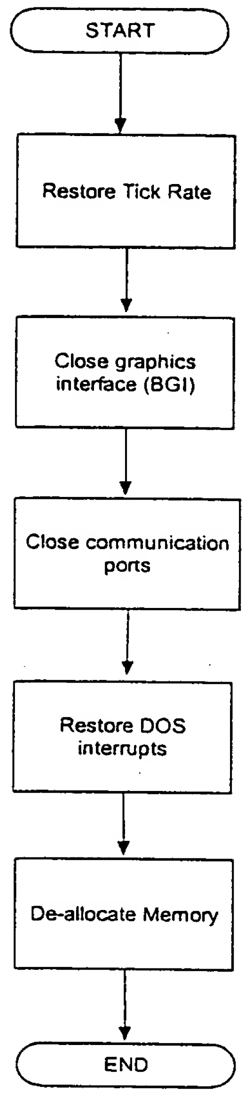
Flag Check Routine

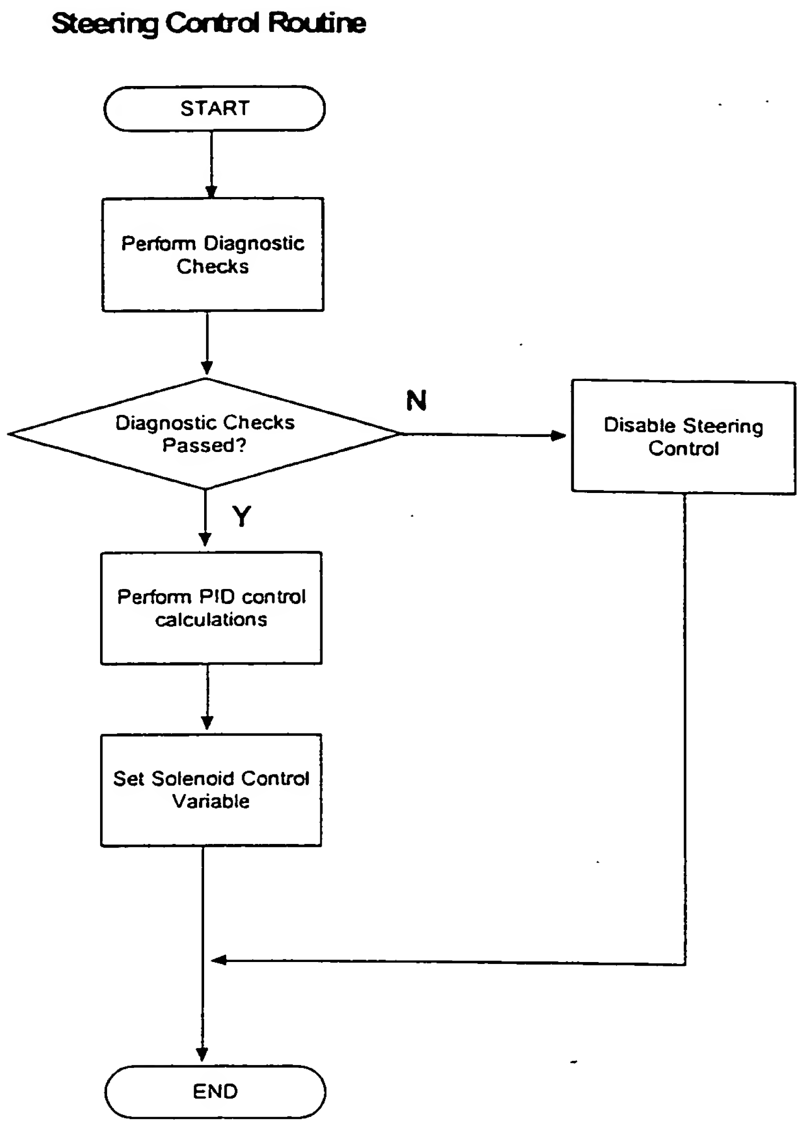


Retrieve and Process New GPS Data Routine

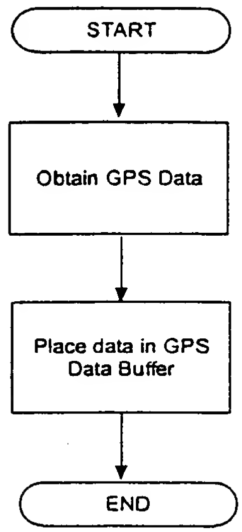


De - Initialisation Routine

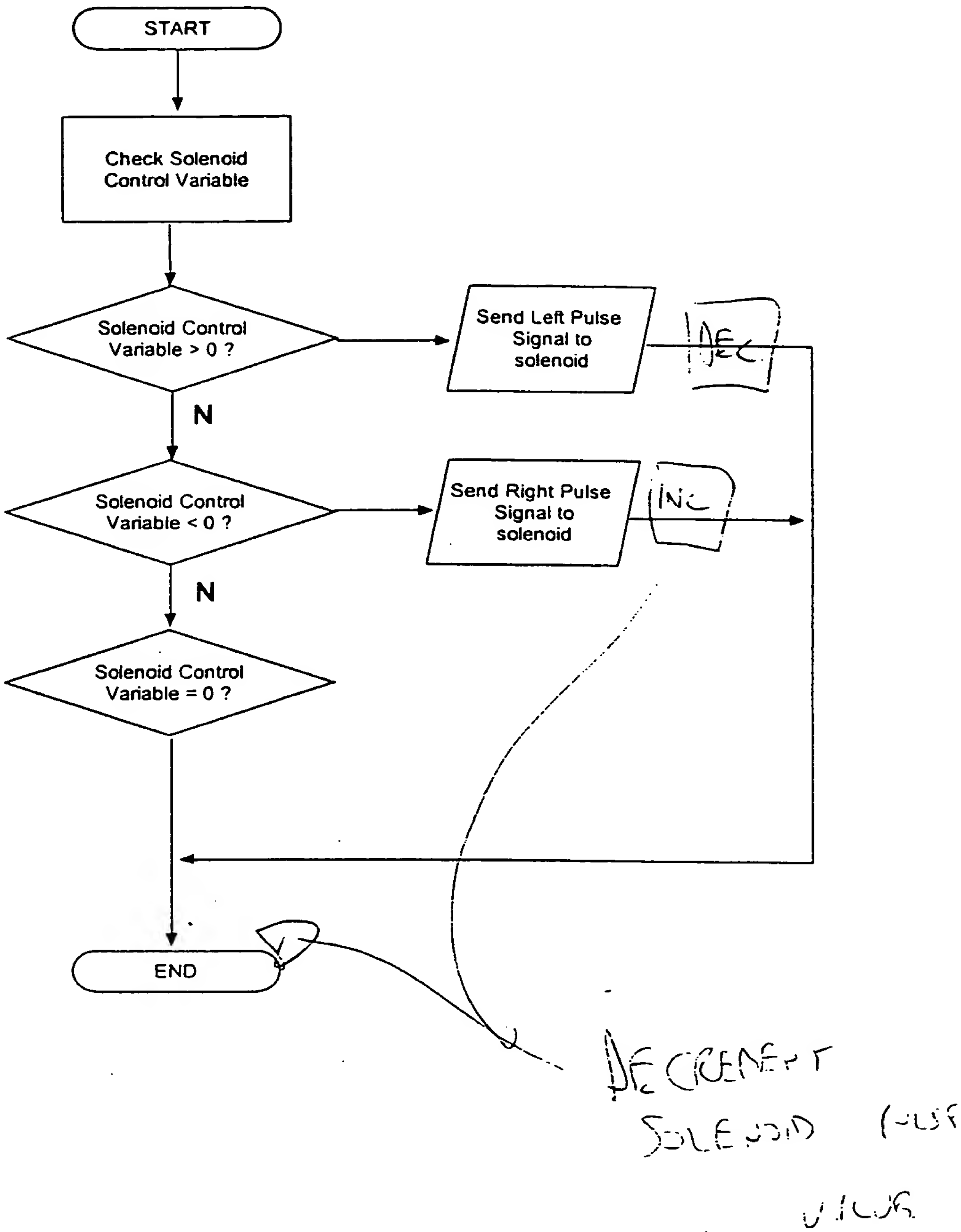



Steering Control Routine
START
Perform Diagnostic Checks
Diagnostic Checks Passed?
N
Disable Steering Control
Y
Perform PID control calculations
Set Solenoid Control Variable
END

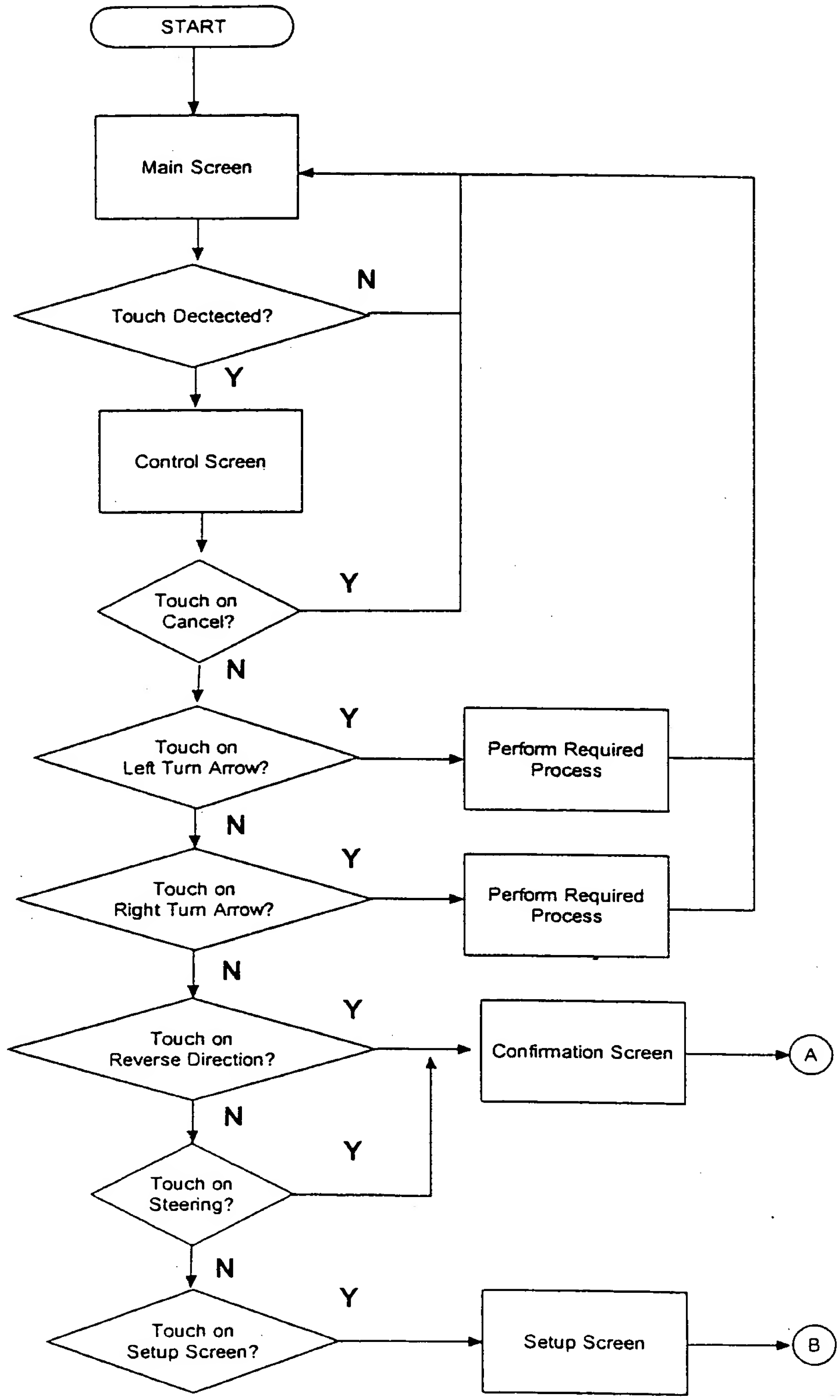
GPS Data Ready Interrupt Driven Routine



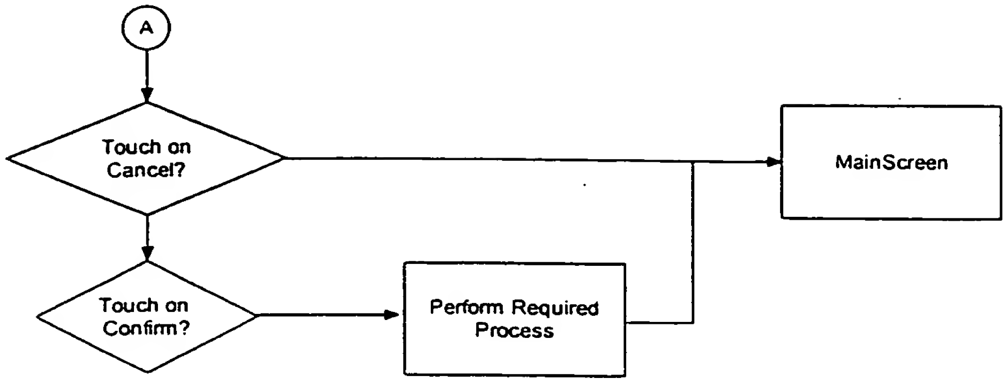
System Timer Tick Interrupt Driven Routine



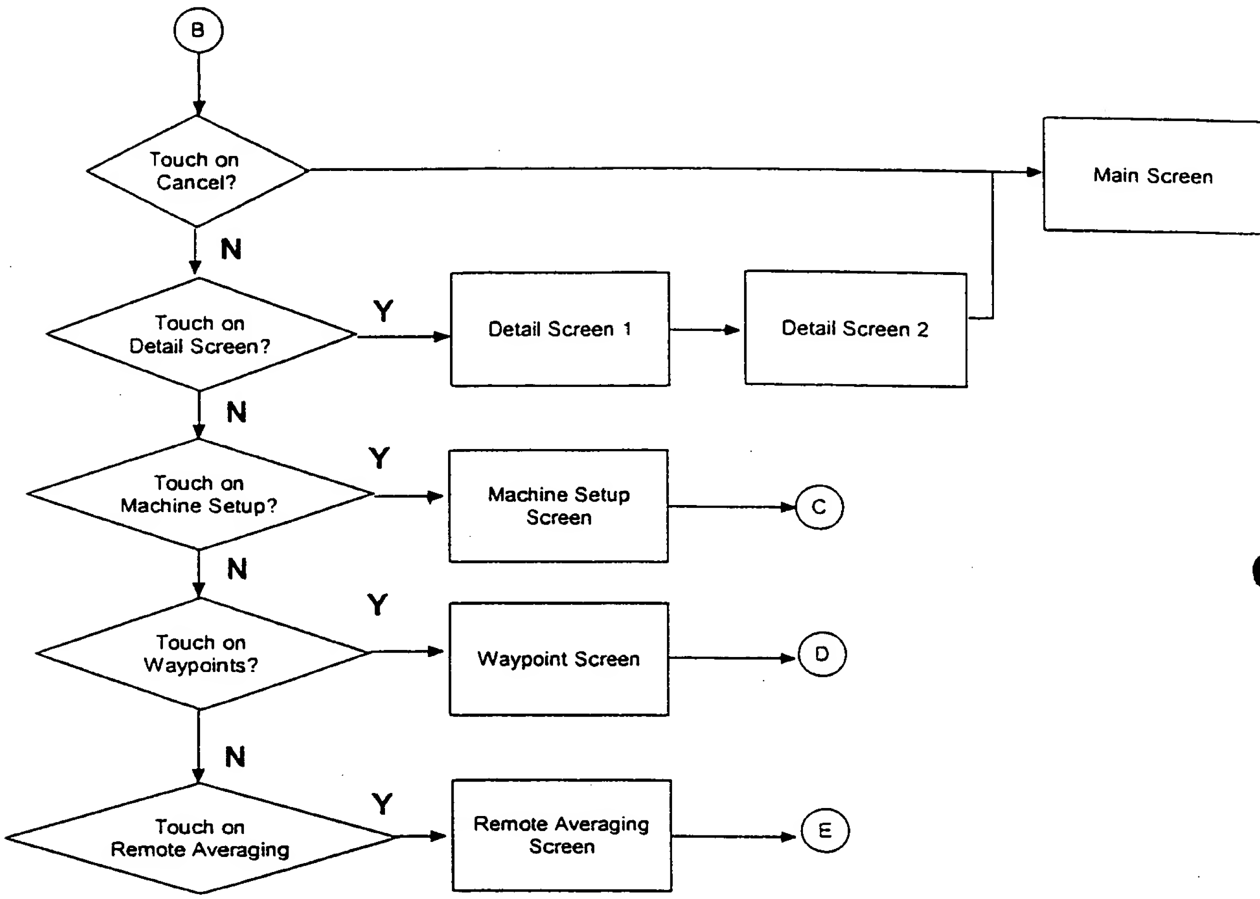
Process User Input Routine



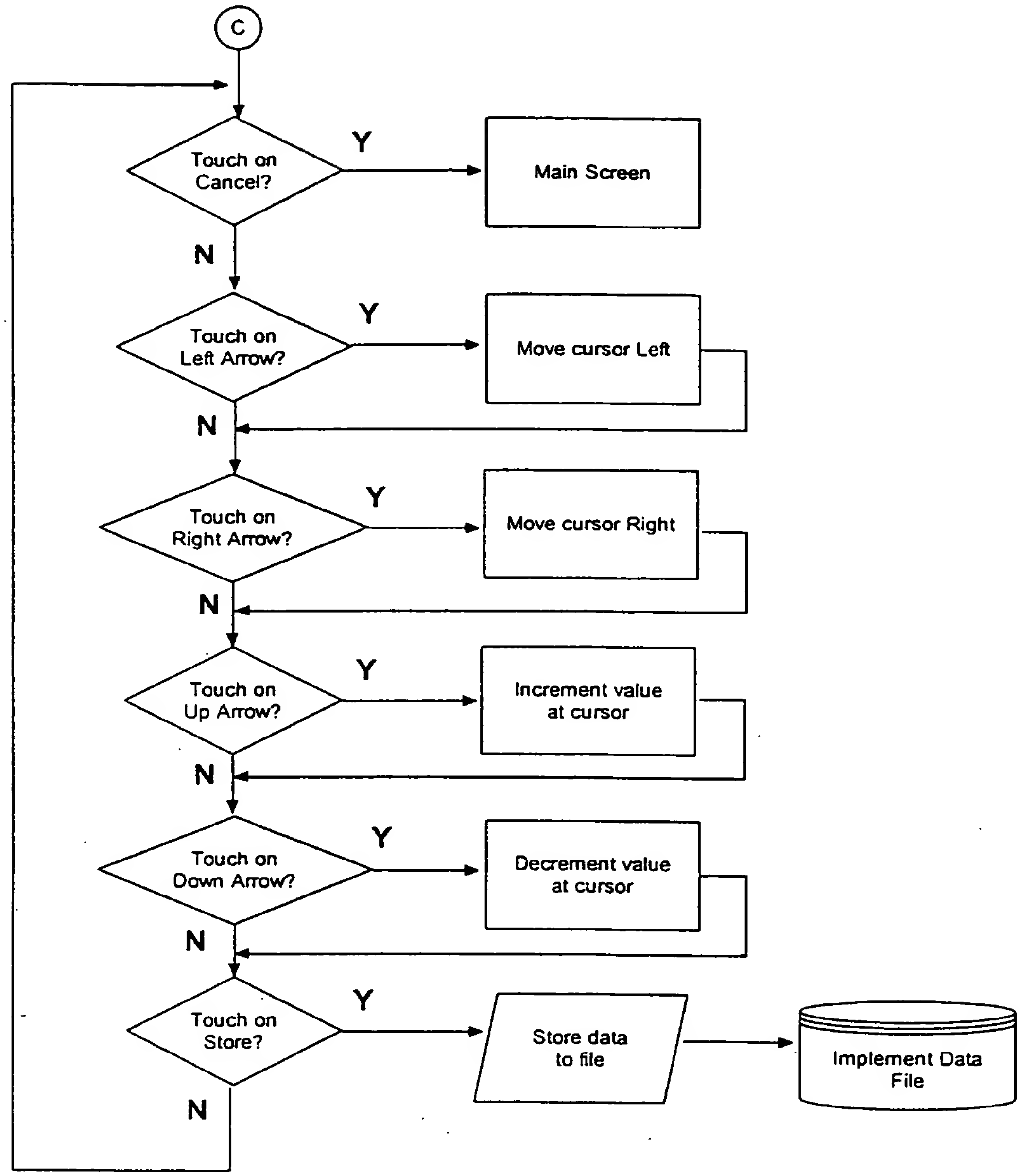
Process User Input Routine



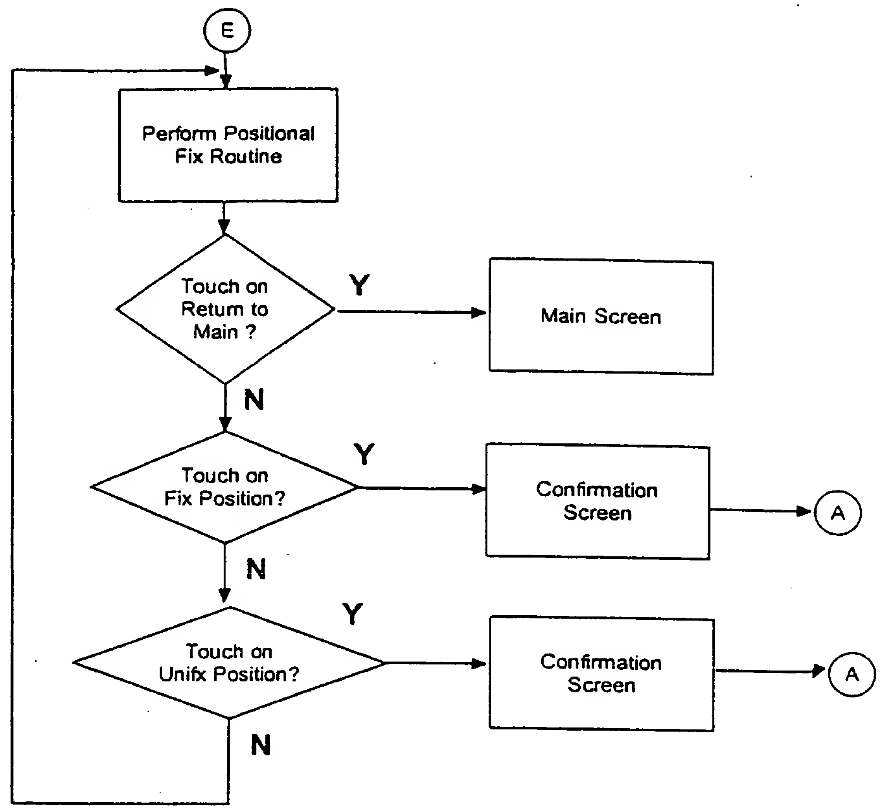
Process User Input Routine



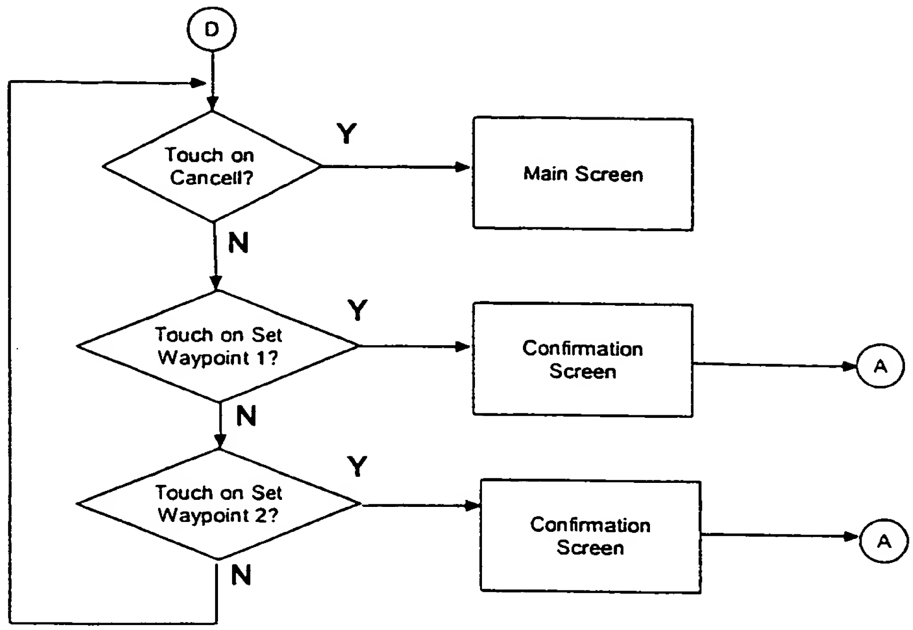
Process User Input Routine

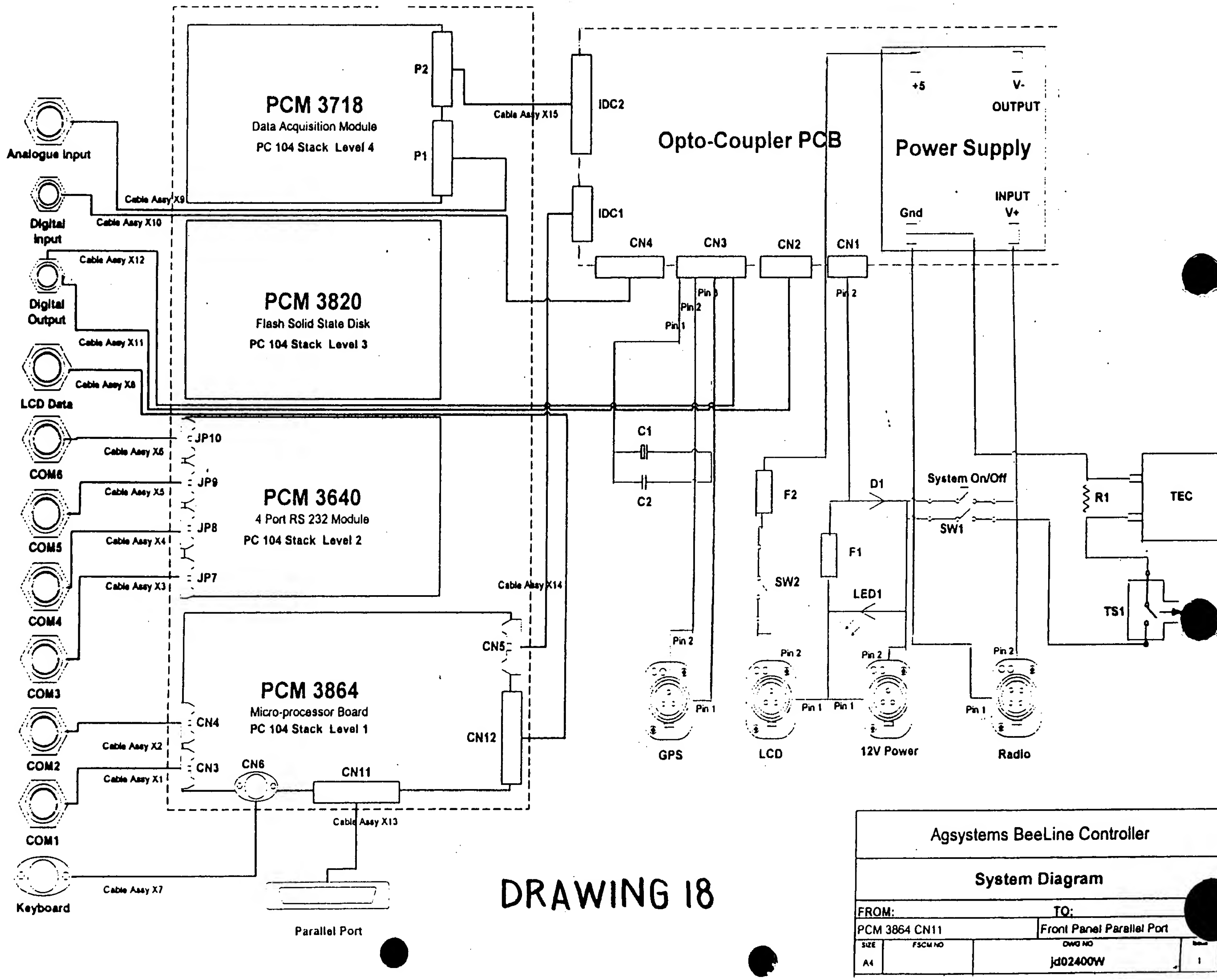


Process User Input Routine

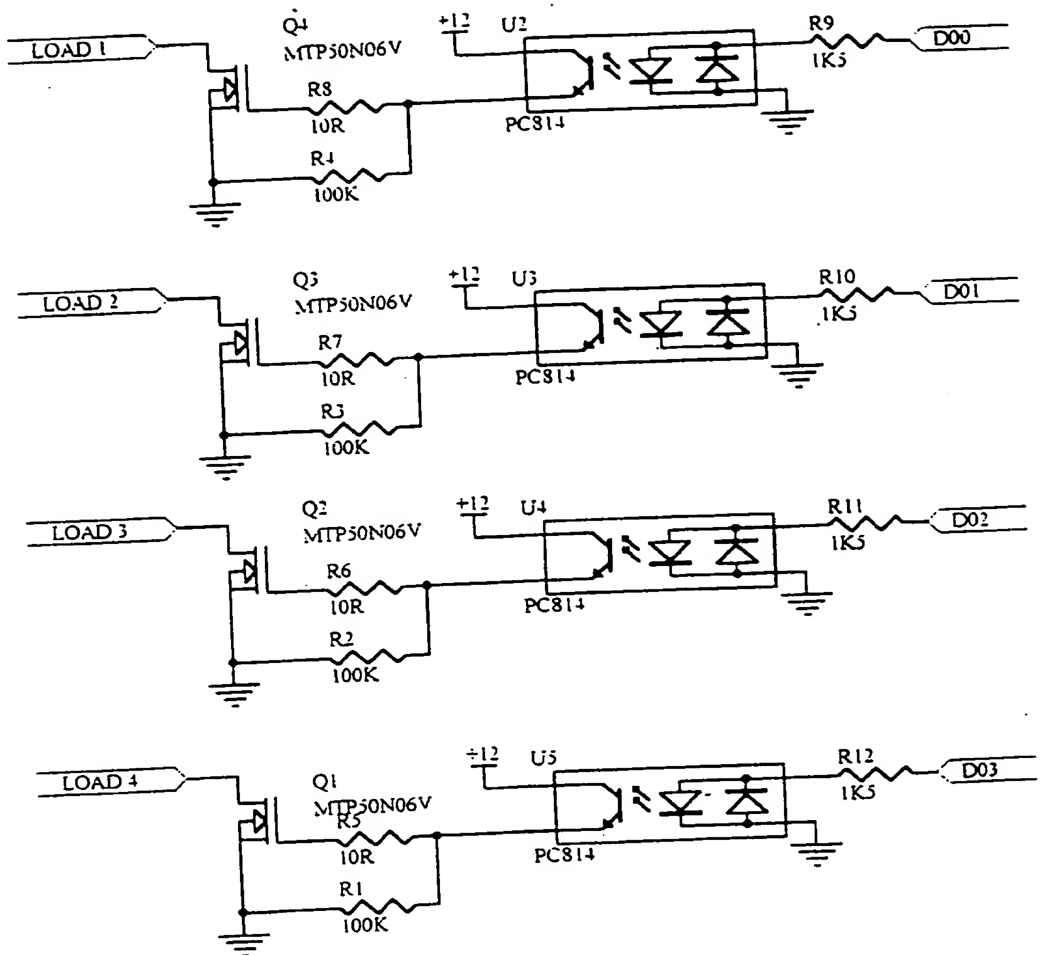


Process User Input Routine




PCM 3718
Data Acquisition Module
PC 104 Stack Level 4
P2
P1
PCM 3820
Flash Solid State Disk
PC 104 Stack Level 3
PCM 3640
4 Port RS 232 Module
PC 104 Stack Level 2
JP10
JP9
JP8
JP7
PCM 3864
Micro-processor Board
PC 104 Stack Level 1
CN4
CN3
CN6
CN11
CN12
CN5
Opto-Coupler PCB
IDC2
IDC1
CN4
CN3
CN2
CN1
Pin 3
Pin 2
Pin 1
Power Supply
+5
V-
OUTPUT
INPUT
Gnd
V+
C1
C2
F2
SW2
F1
D1
LED1
System On/Off
SW1
R1
TEC
TS1
Pin 2
Pin 1
GPS
LCD
12V Power
Radio
Analogue Input
Digital Input
Digital Output
LCD Data
COM6
COM5
COM4
COM3
COM2
COM1
Keyboard
Parallel Port
Cable Assy X15
Cable Assy X9
Cable Assy X10
Cable Assy X12
Cable Assy X11
Cable Assy X8
Cable Assy X6
Cable Assy X5
Cable Assy X4
Cable Assy X3
Cable Assy X14
Cable Assy X2
Cable Assy X1
Cable Assy X13
Cable Assy X7
Agsystems BeeLine Controller
System Diagram
FROM:
PCM 3864 CN11
TO:
Front Panel Parallel Port
SIZE
A4
FSCM NO
DWG NO
jd02400W
1

DRAWING 18


LOAD 1
Q4
MTP50N06V
R8
10R
R4
100K
+12
U2
PC814
R9
1K5
D00
LOAD 2
Q3
MTP50N06V
R7
10R
R3
100K
+12
U3
PC814
R10
1K5
D01
LOAD 3
Q2
MTP50N06V
R6
10R
R2
100K
+12
U4
PC814
R11
1K5
D02
LOAD 4
Q1
MTP50N06V
R5
10R
R1
100K
+12
U5
PC814
R12
1K5
D03

DRAWING 19

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